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Application to the ESA Astronaut Program

Current research summary:

My research focuses on the analysis of current and future observations of exoplanets to understand the physics and the chemistry of their atmospheres. Using data-oriented techniques, I have characterised the atmosphere of planets ranging from the temperate super-Earth LHS-1140b to the extremely-hot Jupiter KELT-9b. I have pioneered in the characterisation of degenerate behaviours through simulated and real data analyses and developed new tools adapted to the study of large populations and phase curve observations. I also used those tools to evaluate the performances of next generation telescopes such as ESA Ariel and NASA/ESA JWST in answering some of the major questions of the field. My approach emphasises on the importance of mixing multiple disciplines to better understand exoplanet atmospheres.

Current position:

2021 – Present: Research fellow in exoplanetary atmospheres and Ariel performances (*University College London)*

Key roles:	Coordinator of the Spectral Retrieval working group for the ESA Ariel Mission.
	Developer of the *TauREx* and *Alfnoor* exoplanet suites.
	Founder of the UCT collaboration between UCL and the Tokyo University exoplanet groups.
	Project leader ``Towards population studies of exoplanetary atmospheres''.
	Project leader ``Planetary atmospheres are not 1D ''.
Press:	The Conversation: ``How can some planets be hotter than stars?''.
	Science & Vie: ``Le mystère des planètes vaporeuses''.

Education:

- **2018-2021:** <u>PhD in Astrophysics</u> - *University College London* (London, UK) – Title: Next generation techniques to characterise exoplanetary atmospheres – Supervisor: Prof. Giovanna Tinetti.
- **2017-2018:** <u>Master (MASt) in Applied Mathematics (Part III)</u> - *University of Cambridge* (Cambridge, UK) – Grade: 71%
- **2015-2016:** <u>Master (MSc) in Environmental Technology</u> - *Imperial College London* (London, UK) – Grade: Merit
- **2013-2016:** <u>Master (MEng) in General Engineering</u> - *Ecole des Mines* (Douai, FRA) – Grade: 15.1/20
- **2010-2013:** <u>CPGE: Equiv. Bachelor Degree in Mathematics/Physics</u> - *Lycée Daudet* (FRA) – Grade: A

Research Articles:

(8 main author articles and 20 co-authored works from 2019 to Present)

[1] **Changeat** et al. (2021): An exploration of model degeneracies with a unified phase curve retrieval analysis: The light and dark sides of WASP-43 b, ApJ - arXiv:2103.14566.

[2] **Changeat** and Edwards (2021): The Hubble WFC3 Emission Spectrum of the Extremely-Hot Jupiter, KELT-9b, ApJL - arXiv:2101.00469.

[3] **Changeat**, et al. (2020): KELT-11b: Abundances of water and constraints on carbon-bearing molecules from the Hubble transmission spectrum, ApJ - arXiv:2010.01310.

[4] **Changeat** and Al-Refaie (2020): TauREx3 PhaseCurve: A 1.5D model for phase curve description, ApJ - arXiv:2006.14237.

[5] **Changeat**, et al. (2020): Alfnoor: A Retrieval Simulation of the Ariel Target List, AJ - arXiv:2003.01839.

[6] **Changeat**, et al. (2020): Disentangling Atmospheric Compositions of K2-18 b with Next Generation Facilities, Submitted.

[7] **Changeat**, et al. (2020): Impact of planetary mass uncertainties on exoplanet atmospheric retrievals, ApJ - arXiv:1908.06305

[8] **Changeat**, et al. (2020): Towards a more complex description of chemical profiles in exoplanets retrievals: A 2-layer parameterisation, ApJ - arXiv:1903.11180.

[9] Tinetti et al. (2021) : Ariel: Enabling planetary science across light-years, Experimental Astronomy - arXiv:2104.04824.

[10] Mugnai et al. (2021): ARES V: No Evidence For Molecular Absorption in the HST WFC3 Spectrum of GJ 1132 b, AJ - arXiv:2104.01873.

[11] Ito, **Changeat** et al. (2021) : Detectability of Rocky-Vapour Atmospheres on Super-Earths with Ariel, Experimental Astronomy - arXiv:2103.04342.

[12] Turrini et al. (2021): Tracing the formation history of giant planets in protoplanetary disks with Carbon, Oxygen, Nitrogen and Sulphur, AJ - arXiv:2012.14315.

[13] Yip, **Changeat**, et al. (2020): Peeking inside the Black Box: Interpreting Deep Learning Models for Exoplanet Atmospheric Retrievals, ApJ - arXiv:2011.11284.

[14] Edwards, **Changeat**, et al. (2020): Hubble WFC3 Spectroscopy of the Habitable-zone Super-Earth LHS 1140 b, ApJ - arXiv:2011.08815.

[15] Guilluy et al. (2020): ARES IV: Probing the atmospheres of the two warm small planets HD 106315 c and HD 3167 c with the HST/WFC3 camera, ApJ - arXiv:2011.03221.

[16] Yip, **Changeat**, et al. (2020): On the Compatibility of Ground-based and Space-based Data: WASP-96 b, An Example, ApJ - arXiv:2009.10438.

[17] Anisman et al. (2020): WASP-117 b: an eccentric hot-Saturn as a future complex chemistry laboratory, ApJ - arXiv:2009.08916.

[18] Edwards, Anisman, **Changeat** et al. (2020): Original Research By Young Twinkle Students (ORBYTS): Ephemeris Refinement of Transiting Exoplanets II, RNAAS - arXiv:2007.07232.

[19] Pluriel et al. (2020): ARES III: Unveiling the Two Faces of KELT-7 b with HST WFC3, ApJ - arXiv:2006.14199.

[20] Skaf et al. (2020): ARES II: Characterising the Hot Jupiters WASP-127 b, WASP-79 b and WASP-62 b with HST, ApJ - arXiv:2005.09615.

[21] Edwards, **Changeat**, et al. (2020): ARES I: WASP-76 b, A Tale of Two HST Spectra, ApJ - arXiv:2005.02374.

[22] Edwards, **Changeat**, et al. (2020): Original Research By Young Twinkle Students (ORBYTS): Ephemeris Refinement of Transiting Exoplanets, MNRAS - arXiv:2005.01684.

[23] Bourgalais, Carrasco, **Changeat**, et al. (2020): Ions in the Thermosphere of Exoplanets: Observable Constraints Revealed by Innovative Laboratory Experiments, ApJ - arXiv:2004.12872.

[24] Barstow, **Changeat**, et al. (2020): A comparison of exoplanet spectroscopic retrieval tools, MNRAS - arXiv:2002.01063
[25] Drummond et al. (2020): Implications of three-dimensional chemical transport in hot Jupiter atmospheres: results from a consistently coupled chemistry-radiation-hydrodynamics model, A&A - arXiv:2001.11444.

[26] Venot et al. (2020): Global Chemistry and Thermal Structure Models for the Hot Jupiter WASP-43b and Predictions for JWST, ApJ - arXiv:2001.04759.

[27] Yip et al. (2020): Pushing the Limits of Exoplanet Discovery via Direct Imaging with Deep Learning, ECML-PKDD - arXiv:1904.06155.

[28] Al-Refaie, **Changeat**, et al. (2020): TauREx III: A fast, dynamic and extendable framework for retrievals, Submitted - arXiv:1912.07759.

Participation to conferences, talks and invitations:

- **2020 Dec:** Talk at the ARES day (virtual).
- **2020 Mar- Apr:** Research visit and invited talk (Tokyo University): Long term collaboration with the Tokyo exoplanet group on interactions between atmospheres and interiors.
- **2020 Jan:** Poster presentation at the Ariel public conference (ESA-ESTEC).
- **2020 Jan:** Talk and poster presentations at the Rocky Exo-worlds conference (University of Cambridge).
- **2019 Nov:** Invited research visit (Edinburgh University). Collaboration and preparation of a research article.
- **2019 Oct:** Participation to the Okinawa Exoplanet conference and research visit to Tokyo University (Japan).
- **2019 Sep:** Talk at the EPSC-DPS conference (Lyon).
- **2019 Aug:** Poster presentation at the Extreme Solar System conference (Iceland).
- **2019 Aug:** Attendance and poster presentation at the NASA TESS general conference (MIT).
- **2019 Jul:** Research visit and invited talk (University of California Berkeley).
- **2019 Jul:** Research visit and invited talk (NASA JPL centre).
- **2019 Jul:** Research visit and invited talk (California Institute of Technology).
- **2019 Feb:** Participation to the NASA TESS Workshop (Space Telescope Science Institute).
- **2019 Feb:** Research visit to Columbia University (invited by Prof. David Kipping).
- **2019 Feb:** Talk at the UCL APEX seminar series (UCL).
- **2019 Feb:** Organisation and animation of a TauREx 2h-tutorials for the Digital Exoplanets conference (Prague).

- **2018 - Present:** Participation and presentations to ESA Ariel Consortium meetings (about 15 presentations).

Summer Schools:

- **2021 Sep:** Organisation and teaching at the 2021 edition of ARES: Ariel Summer School 2.
- **2019 Sep:** Teaching at the 2019 edition of ARES: Ariel Summer School 1.
- **2019 Jul:** Poster presentation at the Sagan Summer School in Caltech.
- **2019 Jun:** Participation to the PennState Summer School in Astrostatistics.
- **2019 Mai:** Participation to the ASES3 Summer School in Vietri.

Teaching and Public events:

- **2021 Summer: Supervision of summer internships –** Lorenzo Pica Ciamarra**.**
- **2020 to Present: Supervision MSc thesis -** Alexandra Thompson: this led to a PhD offer.
- **2020 Dec: Astronomines Conference (Online) -** Invited public talk at Ecole des Mines Saint-Etienne.
- **2019: Supervision MSc thesis -** Luke Keyte: this led to a publication and a PhD offer.
- **2019 Nov: Conférence Astronomie (Ales) -** Series of 3 public talks and interventions (open to all, reserved for students, for literature students) at Lycee Jacque Prevert and Saint-Christol-les-Ales.
- **2019 Oct: Public talk Tokyo Space Cafe (Tokyo) -** Public talk.
- **2019 Sep: Ariel Summer School ARES (Biarritz) -** Teaching to about 20 PhD/PostDocs the use of atmospheric retrieval tools. This led to 5 co-publications.
- **2018 - 2019: Marking -** Marking of coursework and exams for the UCL Exoplanet course.
- **2018 - 2020: ORBYTS teaching program -** Weekly teaching of exoplanet science for high school student. Planification of observations with the LCO and TelescopeLive networks to characterise ephemerids of transiting planets. Two publications.

Awards and prizes:

- **2019 Sep:** CNES funding to teach at the Biarritz Summer School.
- **2019 Aug:** NASA/MIT bursary to attend the TESS conference.
- **2019 Jul:** NASA scholarship to attend and the Sagan Summer School at Caltech.
- **2019 May:** Europlanet grant to participate to the ASES3 Summer School in Vietri.
- **2019 Oct:** ESA bursary to attend the Ladybird training course.
- **2018 Oct:** E.M. Burnett Prize in recognition of excellent results from Cambridge University.
- **2015 Dec:** Ecole des Mines grant supporting the double degree with Imperial College London.

Other Professional experiences:

- **2018 Sept: ESA Ladybird Guide to Operation Spacecraft training course** (Libramont, BE)
1-week course on spacecraft operations, learning through practical examples. Simulation of a spacecraft failure.

- **2016 Oct – 2017 Sep: Consultant in IT at Wavestone** (Paris, FRA)
Designing and securing Alstom new IT system by giving cybersecurity advices, assessing IT operations (flow openings, VPN configurations, security exceptions…) and more generally assisting every level of their IT migration.

- **2015 Nov - 2016 Feb: Freelance Consultant in Aerospace at OutSmart Insights Ltd** (London, UK)
Technology scanning and advices for an aerospace company (BAE Systems). Identification of key technologies and their applications to jet aircrafts. Assessment of TRL and patent identification.

- **2015 May-Sept: Internship at TOTAL SA. Study of R&D localization** (Pau, FRA)
Assistance to TOTAL's strategy of R&D reorganisation by comparing the R&D potential of 11 countries. Use of a multicriteria approach based on analysing reports and conducting interviews with TOTAL's collaborators.

Other Research Projects:

- 2018 Jan-May: MASt Essay on "Redshift Space Distortion" at the University of Cambridge.
Exploring how peculiar velocity impacts the observed repartition of galaxies. Understanding and reproducing main literature results. Calculation of the power spectrum in Kaiser linear and CLPT cases.

- 2016 Apr-Oct: MSc Thesis on "The impact of Shading and orientation issues on Solar Panels performances" at Imperial College London.
Building of a statistical method to detect solar panels with shading and orientation issues. Creation of a java software to analyse a large dataset of panel outputs. Assessment of the amount of energy lost in UK due to these issues.

- 2015 Jan-May: Research Project on "Low Reynold flows around Ellipsoid obstacles" at Ecole des Mines.
Study of the impact of variables (flow speed, flow characteristics, obstacle shape, obstacle angle) on drag and lift coefficients through numerical simulations with ANSYS Fluent.

- 2014 May-Aug: Internship on "Small cost collaborative energy solution for summerhouses" at Aalborg University.
Creation of a thermal model for off-grid summerhouses and comparison of energy solutions for providing autonomous heat and electricity. Temperature monitoring and data analysis.

- 2013 Jan-Jul: Research Project on "Numerical and Perturbative methods for the 3-bodies problem" at Lycée Daudet.
Creation of a 3-Dimentional model (programmed in Java + OpenGL) in order to compare the Perturbative and the Runge Kutta methods for the 3-Bodies problem. Assessment on the Sun-Earth-Moon system and comparison with the Online NASA database.

Languages, Skills and Hobbies:

Languages:
- French: Mother tongue
- English: Fluent (TOEIC 905/990 – IELTS 7,5/9)

Computer Skills:
- Numerical Modelling (ANSYS, Solidworks)
- Programming (C, Python, Java, HTTP)

Hobbies:
- Telescope observations
- Plane pilot training (PPL license) & Gliding
- Skiing: Competition & teaching (23 years).
- Volleyball: Alès and Douai Clubs (8 years)
- Kitesurfing (10 years)